

Field Sampling Plan for Lysimeter and Perched Water Monitoring of Operable Unit 7-13/14

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September 2005

**Idaho
Cleanup
Project**

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**Idaho Cleanup Project
Idaho Falls, Idaho 83415**

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ABSTRACT

Monitoring for vadose zone contaminants in the Subsurface Disposal Area and around the Radioactive Waste Management Complex (RWMC) within the Idaho National Laboratory Site is conducted as part of the Idaho Cleanup Project's monitoring program. This plan outlines the sampling objectives, locations, priorities, data evaluation, and process for Operable Unit 7-13/14 vadose zone monitoring at the RWMC. The objectives of vadose zone monitoring are to determine if contaminants have migrated from the waste zone of the Subsurface Disposal Area at the RWMC to surrounding soils and perched water layers, and collect data on the spatial extent of contamination. Data obtained from perched water and soil moisture monitoring are used to support several purposes and programs including the Waste Area Group 7 comprehensive remedial investigation/feasibility study, fate and transport modeling, Idaho National Laboratory oversight groups, and subsurface sciences at the RWMC.

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ACRONYMS

| | |
|-------|--|
| CFR | Code of Federal Regulations |
| COC | contaminant of concern |
| CRDL | contract-required detection limit |
| DOE | U.S. Department of Energy |
| EPA | U.S. Environmental Protection Agency |
| FSP | field sampling plan |
| FTL | field team leader |
| GFAA | graphite furnace atomic adsorption |
| INL | Idaho National Laboratory |
| MCL | maximum contaminant level |
| MCP | management control procedure |
| OU | operable unit |
| QA | quality assurance |
| QAPjP | quality assurance project plan |
| QC | quality control |
| RBC | risk-based concentration |
| RCRA | Resource Conservation and Recovery Act |
| RWMC | Radioactive Waste Management Complex |
| SAM | Sampling and Analysis Management |
| SAP | sampling and analysis plan |
| SDA | Subsurface Disposal Area |
| TPR | technical procedure |
| TSA | Transuranic Storage Area |
| USGS | U.S. Geological Survey |

Field Sampling Plan for Lysimeter and Perched Water Monitoring of Operable Unit 7-13/14

1. INTRODUCTION

1.1 Scope

This field sampling plan (FSP) supports the comprehensive Waste Area Group 7 remedial investigation/feasibility study under the *Federal Facility Agreement and Consent Order* (DOE-ID 1991) at the Radioactive Waste Management Complex (RWMC). The role of lysimeter and perched water monitoring under the Operable Unit (OU) 7-13/14 investigation is to monitor and characterize contaminant migration in the soil moisture and perched water Subsurface Disposal Area (SDA) vadose zone within the RWMC to support efforts to protect the quality of the Snake River Plain Aquifer.

Together, this FSP and the *Quality Assurance Project Plan for Waste Area Groups 1, 2, 3, 4, 5, 6, 7, 10, and Deactivation, Decontamination, and Decommissioning* (DOE-ID 2004) are considered the sampling and analysis plan for the project. This FSP has been prepared in accordance with the Idaho Cleanup Project management control procedure (MCP), “Environmental Sampling Activities at the INEEL” (ICP-MCP-9439) and describes the field activities that are part of the investigation. The *Quality Assurance Project Plan* (QAPjP) (DOE-ID 2004) describes the processes and programs that ensure the generated data will be suitable for the intended use.

The Idaho Cleanup Project will collect lysimeter and perched water samples routinely from RWMC area wells to monitor for evidence of contaminant migration from the RWMC SDA and provide data that will aid in characterizing the spatial extent of contamination for the OU 7-13/14 Project. The data collected will aid in the understanding of the fate and transport of contaminant migration from the SDA, help fill previously identified data gaps, and support the selection of appropriate remedial alternatives.

Sampling and analytical activities associated with lysimeters placed in the waste as part of the Probing Project are outside of the scope of this effort and are described in Salomon (2004).

1.2 Idaho National Laboratory Site Background

The Idaho National Laboratory (INL) Site is a U.S. Department of Energy (DOE) facility, located 52 km (32 mi) west of Idaho Falls, Idaho, that occupies 2,305 km² (890 mi²) of the northeastern portion of the Eastern Snake River Plain. The RWMC is located in the southwestern portion of INL Site, as shown in Figure 1-1. The SDA is a 39-hectare (97-acre) area located within the RWMC. The SDA consists of 20 pits, 58 trenches, 21 soil vault rows, Pad A, and the Acid Pit where waste disposal activities occurred.

The *Federal Facility Agreement and Consent Order* (DOE-ID 1991) establishes the procedural framework and schedule for developing, prioritizing, implementing, and monitoring response actions at the INL Site in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (42 USC § 9601 et seq. 1980); the Resource Conservation and Recovery Act (RCRA) (42 USC § 6901 et seq. 1976); and the Idaho Hazardous Waste Management Act (Idaho Code § 39-4401 et seq. 1983). The U.S. Environmental Protection Agency (EPA) proposed listing the INL Site on the National Priorities List of the National Contingency Plan on July 14, 1989 (54 FR 29820). This was done using hazard ranking system procedures found in the National Contingency Plan. The hazard ranking system is a model that evaluates relative potential of uncontrolled hazardous substances to cause human

health/safety or ecological/environmental damage. This system scores the relative potential on a scale of 0 to 100. Sites scoring 28.50 or higher are eligible for the National Priorities List. The score for the INL Site was 51.91. After considering public input during a 60-day comment period following the proposed INEEL listing, the EPA issued a final rule listing the INL Site. The rule was published in the Federal Register on November 21, 1989 (54 FR 48184).

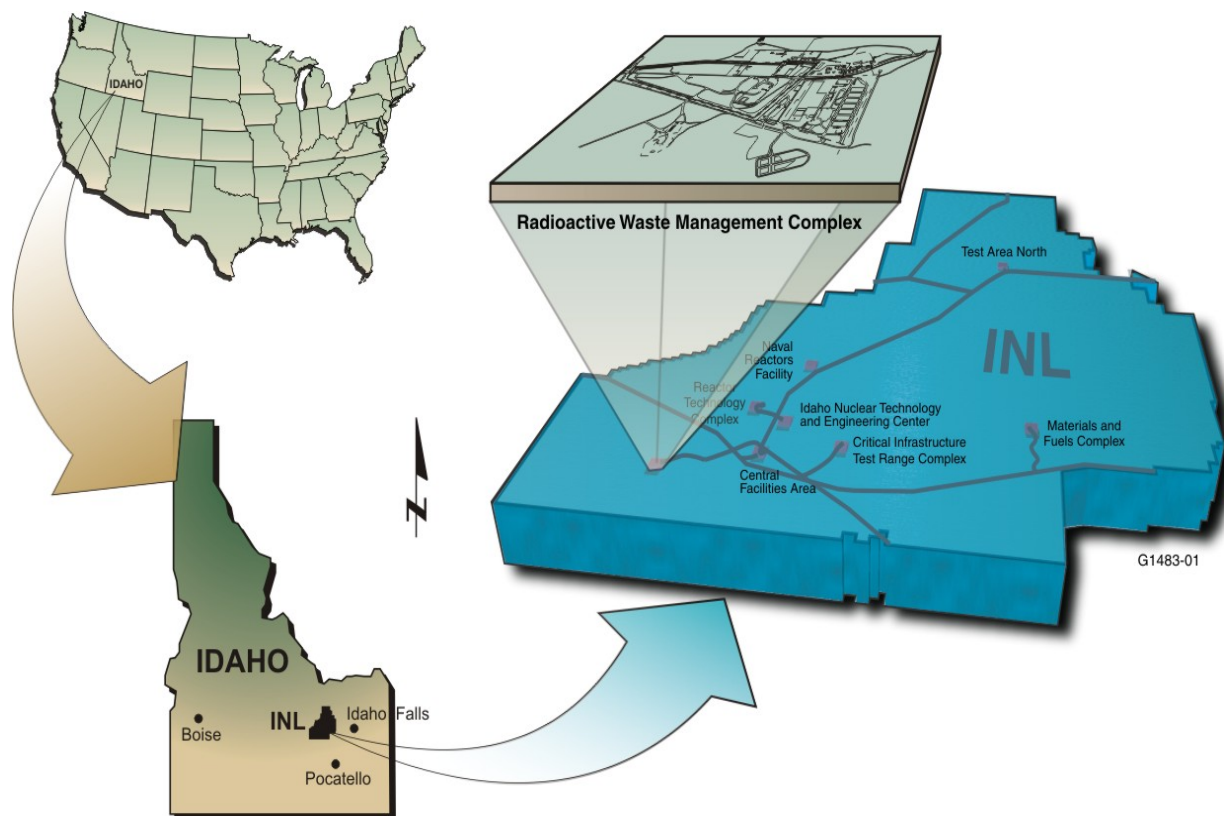


Figure 1-1. Map showing the location of the Radioactive Waste Management Complex at the Idaho National Laboratory Site.

Comprehensive INL Site historical and geological information relevant to the RWMC is provided in the *Ancillary Basis for Risk Analysis of the Subsurface Disposal Area* (Holdren et al. 2002).

1.3 Radioactive Waste Management Complex History

The Atomic Energy Commission selected the RWMC, located in the southwestern corner of the INL Site (Figure 1-1), as a waste disposal site for solid low-level radioactive waste in 1952.

The RWMC encompasses a total of 72 hectares (177 acres) and is divided into three areas by function: the SDA as shown in Figure 1-2, the Transuranic Storage Area (TSA), and the administration and operations area.

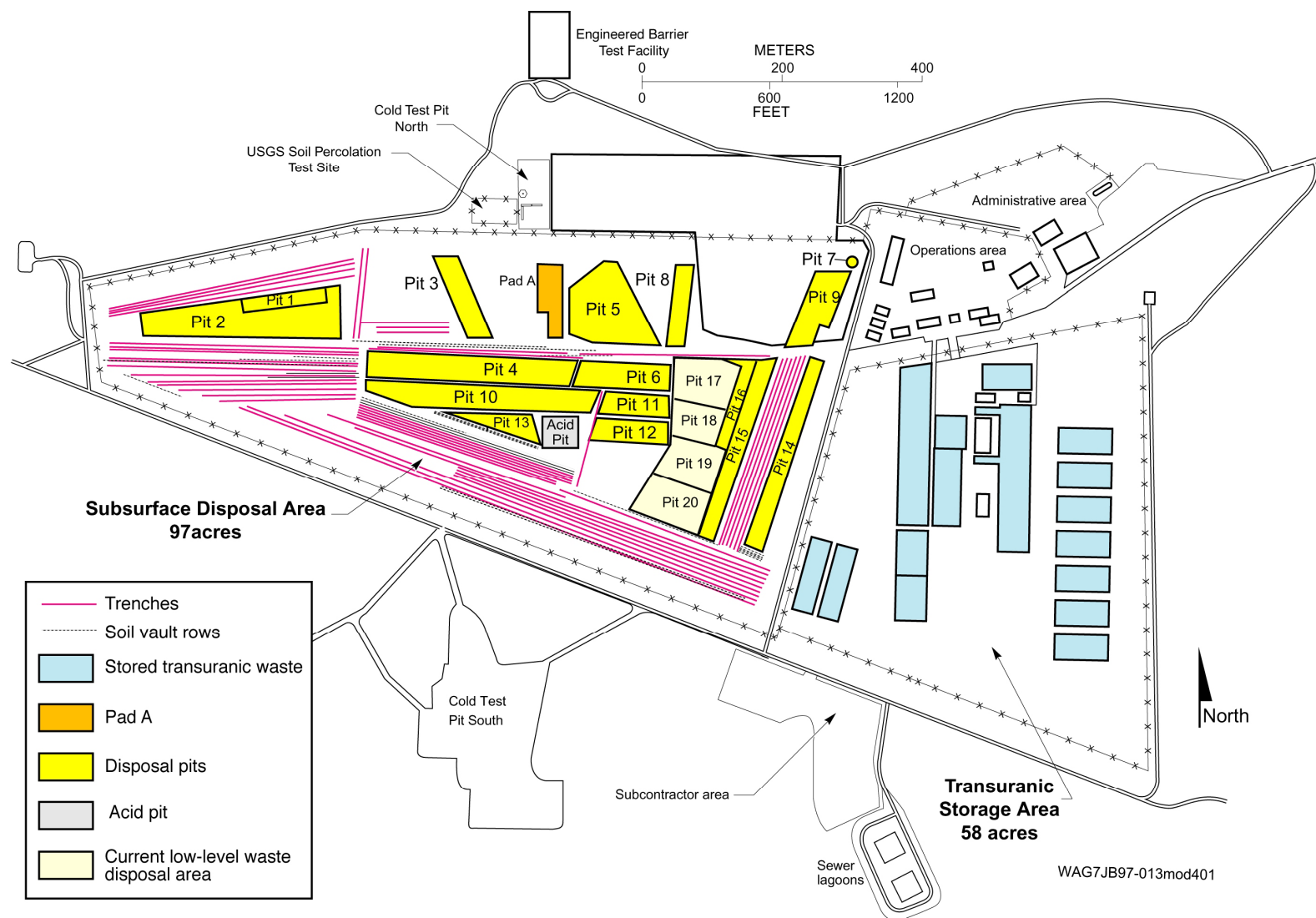


Figure 1-2. Subsurface Disposal Area at the Radioactive Waste Management Complex.

1.3.1 Subsurface Disposal Area

The SDA comprises all property from the center of the RWMC westward and is surrounded by a soil berm and drainage channel. The RWMC was initially established in July 1952 as the National Reactor Testing Station Burial Ground on 5 hectares (13 acres). The facility was expanded incrementally over the years to cover 39 hectares (97 acres). Radioactive and hazardous waste has been disposed of in the SDA, and there is an active disposal area within the SDA, which still receives low-level radioactive waste. Both TRU and low-level waste were buried in pits, trenches, soil vaults, and one aboveground pad (Pad A) since 1952. Some of the disposed nonradioactive hazardous waste contain mercury, beryllium, asbestos, zirconium fines, solidified acids and bases, solvents, degreasing agents, and sodium and potassium salts. Through 1970, the SDA was a disposal site for transuranic and mixed waste, most of which came from the Rocky Flats Plant in Colorado. Mixed waste that contained hazardous chemical and radioactive contaminants was accepted through 1984. Since 1985, waste disposal in the SDA has been limited to low-level radioactive waste from INL waste generators.

1.3.2 Transuranic Storage Area

The TSA is a 23.5-hectare (58-acre) facility located on the east side of the SDA (see Figure 1-2). The TSA was established in 1970 as an interim storage facility when subsurface disposal of waste containing TRU concentrations greater than 100 nCi/g in the SDA was discontinued. Operations at the TSA include waste segregation, examination, and certification in addition to interim storage.

1.3.3 Administration and Operations Area

The 9-hectare (22-acre) administration and operations area contains administrative offices, security and gatehouse operations, radiological control support, maintenance buildings, equipment storage, and miscellaneous support facilities (see Figure 1-2). A more detailed summary of RWMC operations is provided in the *Ancillary Basis for Risk Analysis of the Subsurface Disposal Area* (Holdren et al. 2002).

The current mission of the RWMC Cleanup Project is to provide waste management for the present and future needs of the INL and for assigned DOE off-Site generators of low-level and TRU waste.

1.4 Perched Water and Soil Moisture at the INL Site

Studies over the past 30 years or so have shown that perched water is transitory beneath the RWMC but has been detected in numerous boreholes at various times. Perched water bodies have been repeatedly identified at depths of approximately 24–30 m (80–110 ft) and 61–67 m (200–220 ft), corresponding to the sedimentary B-C and C-D interbeds, respectively. Perched water typically occurs in fractured basalt above the interbeds, and samples are collected within or above the interbeds with either piezometers, bailers, or suction lysimeters. Often, perched water wells are dry or contain very little water. Shallow perched water wells have not yielded water since 1997.

Sources of perched water at the RWMC may be (a) surficial infiltration, (b) water moving laterally from the spreading areas of the Big Lost River, or (c) a combination of sources. Results from moisture monitoring (McElroy 1990) suggest that most of the net infiltration into surficial sediments is seasonal, occurring primarily in the spring when moisture is high and evapotranspiration rates are low. Snowmelt is the major contributor to recharge. A tracer test conducted by the U.S. Geological Survey (USGS) confirmed that at least some of the perched water in Well USGS-092, around 65 m (214 ft) deep, originated from the spreading areas (Nimmo et al. 2002). The four lined sewage evaporation ponds located approximately 122 m (400 ft) south of the SDA should not be a source for perched water. Two of the evaporation ponds collect sanitary wastewater from the current RWMC operations and are lined with

an impermeable plastic membrane. The remaining two ponds were built to support Pit 9 remediation and have compacted soil liners. These two ponds have not been used (INEEL 2001).

Historically, perched water has been observed in association with the B-C interbed in Wells 78-1 and 10V (RWMC-901, 1996). From 1992 to about May 1995, Well 78-1 showed perched water thicknesses of up to 0.27 m (0.9 ft) based on measurements made with a pressure transducer connected to a datalogger and measurements made with a steel tape. Well 78-1 was rebuilt in November 1995 because of concerns regarding open annular space and the possibility that water was entering the wellbore at an intermediate depth. Well 78-1 has been checked routinely for perched water since 1997, but none has been observed. Well 10V drilled in the western part of the SDA in 1994 had perched water with a measured thickness of 0.24–0.37 m (0.8 to 1.2 ft). This well has been monitored routinely for water since January 2002, and only trace water has been observed. This well was primarily completed as a vapor-monitoring well and only has a 1.5-in. piezometer to measure perched water.

The two wells associated with the C-D interbed that have consistently had perched water are Well USGS-092, located near the center of the western half of the SDA, and Well 8802D, located in the northeast part of the SDA (RWMC-901, 1996). These wells are routinely monitored for contaminants to support the Waste Area Group 7 remedial investigation/feasibility study.

1.5 Nature and Extent of Contamination in the SDA Vadose Zone

Site contractors and the USGS have conducted numerous environmental studies and investigations in and around the RWMC to characterize soil moisture and perched water. The *Ancillary Basis for Risk Analysis of the Subsurface Disposal Area* (Holdren et al. 2002) contains a comprehensive presentation and discussion of these RWMC studies. A discussion of detected contaminants in soil moisture, perched water, and groundwater since 1997 is presented in the *Fiscal Year 2004 OU 7-13/14 Environmental Monitoring Report for the Radioactive Waste Management Complex* (Koeppen et al. 2005).

All the analytical data associated with the contaminants of concern (COCs) at the RWMC and identified in the *Second Addendum to the Work Plan for the OU 7-13/14 Waste Area Group 7 Comprehensive Remedial Investigation/Feasibility Study* (Holdren and Broomfield 2004) were compiled and evaluated. The compilation encompasses analytical data from 1971 to 2004, and includes results generated by the DOE, the USGS, and the various site contractors. Besides the COCs, contaminants that are frequently detected or provide good tracers for monitoring contaminant movement in the vadose zone are also discussed and summarized.

Contaminants in the vadose zone that are consistently detected, exhibit concentration trends, and show evidence of migration include (listed in order of their detection frequency):

- Uranium isotopes
- Nitrates
- Tritium
- Chemical constituents of magnesium chloride brine (not COCs)
- Tc-99
- C-14.

Contaminants intermittently detected in the vadose are (in order of detection frequency); Cl-36, Pu-238, Am-241, I-129, and Pu-239/240. The highest density of frequent detections in the vadose zone seems to be located in the vicinity of the B-C interbed; however, some contaminants have also been

detected in the vicinity of the C-D interbed. A few non-COC contaminants with elevated and trending concentrations (e.g., barium, bromine, chlorine, iron, and magnesium) have been detected below the C-D interbed to depths of 126 m (413 ft). Some of the frequently detected contaminants are exhibiting increasing concentration trends, have isotopic ratios that are changing, and show evidence of migration, both vertically and laterally. The concentration increases of some non-COC contaminants at some locations in the vadose zone are changing rather quickly as of lately. Examples of fast-changing concentrations, or contaminant migration, are nitrates at Wells PA02, I-2S, and I-4S. Other contaminants exhibiting rapid concentration changes are sodium and sulfate at Well D06; barium, calcium, chloride, iron, and manganese at Well DE7; Cl:Br ratio at Well USGS-92; and fluoride at Well IE6.

Much analytical evidence shows intermittently detected contaminants (i.e., Cl-36, Pu-238, Am-241, I-129, and Pu-239/240) are not a widespread problem in the vadose zone, nor are they migrating at measurable concentrations.

1.5.1 Uranium Isotopes

Uranium isotopes are regularly detected at concentrations above local background, risk-based concentrations (RBCs), and maximum contaminant levels (MCLs). Most of these detections occur in the shallow and intermediate depth intervals. Eleven lysimeter wells inside the SDA have elevated uranium concentrations that consistently exceed RBCs, six of these wells also exceed the drinking water MCL (40 CFR 141), and eight show uranium to be anthropogenic. There are no long-term uranium concentration trends noted at any of the lysimeter locations, except for Well I-4S; however, there are trends associated with U-238:U-235 ratios where anthropogenic uranium is suspected. Uranium concentrations at Well I-4S, located 30 m (97 ft) beneath Pad A, are currently increasing at a fairly substantial rate, indicating uranium is indeed migrating to deeper depths in this region. Anthropogenic uranium with a slight U-235 enrichment has been confirmed at Well TW1, in Pit 5. Most elevated uranium detections occur in wells around Pad A, Pit 5, and the western end of SDA.

The trend associated with isotopic ratios changed in 2004 indicating migration of anthropogenic uranium in these areas of the vadose zone. The change in isotopic ratios appear to be caused by increasing and decreasing U-235 concentrations. It appears as though a front of U-235 migrated through the vadose zone at these lysimeter locations. Of the eight lysimeter wells identified as having anthropogenic uranium, four have been noticeably affected by the change in isotopic ratios. Three of the four wells are located around Pad A (Wells D06, PA01, and PA02), and the other is located at the west end of the SDA (Well W23).

1.5.2 Nitrate

Nitrate concentrations at many monitoring locations are above the local soil moisture upper background range. However, because of background variability, only five monitoring locations have concentrations high enough above the upper background range to confidently declare nitrates are likely from anthropogenic sources (i.e., Wells D15, I-2S, W08, W25, and 98-4). The high nitrate concentrations are predominantly found in the shallow and intermediate depth intervals. Concentration trends are evident at monitoring Wells I-2S, PA02, and W25. These lysimeters are located by Pad A and in the western part of the SDA at depths around 31, 3, and 5 m (100 ft, 9 ft, and 16 ft), respectively. Nitrates measured at location PA02 by Pad A appear to be migrating downward, because concentrations at I-4S, about 30.5 m (100 ft) below Pad A, have started increasing.

1.5.3 Tritium

Tritium is detected at low concentrations in numerous vadose zone lysimeter locations. Locations where tritium is regularly detected in soil moisture samples appear random, as there are no apparent “hot spots” or spatial patterns to where tritium detections regularly occur. Tritium is routinely detected in vadose zone soil moisture to depths around 67 m (220 ft), but has never been detected at depths greater than 76 m (250 ft). Tritium also appears to be moving in a vapor phase, because it is detected at low concentrations in vapor samples collected from Organic Contamination in the Vadose Zone project vapor ports at depths between 9 and 51 m (28 and 166 ft). Extremely high concentrations of tritium (i.e., 109 pCi/L) are detected in soil gases collected near beryllium blocks.

The major source of tritium is likely from beryllium blocks buried in the SDA. The effect that grouting will have on tritium is unknown, but will be determined over time. Monitoring the distribution and migration of tritium is important to the overall understanding of contaminant movement in the vadose zone. Since it is a mobile contaminant that often co-occurs with activation products that are of concern (e.g., C-14 and Tc-99), tritium monitoring can provide trend detection and early warning of migrating contaminants.

1.5.4 Anions and Metals

Numerous anions and metals, most of which are not COCs, are found in vadose zone soil moisture samples at concentrations well above local background. The analytes with historical concentrations above aquifer background levels and their associated concentration ranges observed since 1992 are listed in Table 1. Many of these elevated anions and metals are not regulated by EPA and therefore do not have assigned MCLs for comparison to measured concentrations. The anions and metals consistently detected at concentrations above background are barium, bromide, calcium, chloride, chromium, fluoride, iron, magnesium, manganese, nickel, potassium, selenium, sodium, and sulfate. Some are fairly widespread throughout the vadose zone and mostly attributed to magnesium chloride brine. Others, such as barium, chromium, iron, nickel, fluoride, and selenium, are not widespread and appear to be unique to particular monitoring locations. For example; barium, iron, and manganese are primarily detected in Well DE7; chromium, iron, and nickel are consistently detected in Well O-7; fluoride is unique to Wells IE6 and PA01; and selenium is regularly detected in Wells D06 and PA01. At some monitoring locations, concentration of chromium, nickel, fluoride, and selenium exceed MCLs; and concentrations of barium, fluoride, iron, manganese, and selenium are increasing at Wells DE7, D06, IE6, and PA01.

Brine constituents (i.e., bromide, chloride, magnesium, sodium and sulfate) are consistently detected in vadose zone soil moisture to depths around 31 m (100 ft), with frequent detections at depths around 67 m (220 ft), and recent detections at depths of 126 m (413 ft). Brine contaminants continue to migrate through the SDA vadose zone, as detections in the intermediate and deep regions of the SDA vadose zone are becoming more frequent and widespread. Brine appears to be widely distributed in the vadose zone at relatively high and increasing concentrations. There are increasing concentration trends primarily associated with bromide, chloride, sodium, and sulfate and are most evident in Wells D06, PA02, USGS-92, W05, 8802D, and 98-1. Brine affects the chemistry of soil water by ion exchange, as evidenced by elevated brine constituents and changes in anion ratios. Higher mineral content and altered chemistry of the soil water accelerates the migration of some waste contaminants. Because the chemical constituents of brine are corrosive, they likely have contributed to the premature corrosion and deterioration of waste containers in the SDA. Current analytical data and calculated migration rates of brine constituents (Hull and Bishop 2003) suggest that brine may be responsible for some of the elevated anion and cation concentrations in the Snake River Plain Aquifer beneath the RWMC.

Monitoring the distribution and migration of chloride is important to understanding water and contaminant movement. Since brine can alter soil pore water and soil chemistry via anion and cation exchange, this may affect migration rates of certain contaminants. Brine is also very corrosive and will likely accelerate the corrosion and deterioration of waste containers.

1.5.5 Technetium-99

Technetium-99 is consistently detected at depths to 27 m (88 ft) in Lysimeter Well D06, by Pad A, and Well W23, at the west end of the SDA. The concentration associated with Well D06 is increasing and approaching the aquifer $1\text{E-}05$ RBC. Because of its solubility, mobility, depths of detection, and frequency of detection at certain locations, there is a possibility that Tc-99 is more prevalent in the vadose than it seems. There are areas where Tc-99 is disposed that have yet to be sampled; actually there are many areas of the SDA vadose zone that are not monitored.

1.5.6 Carbon-14

Carbon-14 concentrations around the beryllium blocks are substantially higher than C-14 concentrations near the activated steel or low-level waste disposals. Carbon-14 is only detected intermittently in soil moisture samples, but is readily detected in vapor samples collected near beryllium blocks and activated stainless steel, and is also detected in vapor samples collected from Organic Contamination in the Vadose Zone project vapor ports at depths from 11 to 51 m (35 to 166 ft).

Collecting C-14 samples with suction lysimeters (vacuum) is a significant monitoring concern because the sampling process may volatilize the C-14 and produce nondetections or biased-low concentrations. This may explain why C-14 is only intermittently detected in soil moisture samples.

2. SAMPLING OBJECTIVES AND ANALYTICAL PRIORITIES

Radioactive and hazardous waste has been disposed of in unlined pits, soil vaults, and trenches in the SDA with the potential to leach into the vadose zone and ultimately impact the aquifer. The primary objectives in collecting lysimeter and perched water samples are to determine whether contaminants are leaching from the waste in the SDA and provide data that will aid in characterizing the spatial extent of contamination. The data collected will aid in the understanding of fate and transport of contaminant migration from the RWMC SDA, help fill previously identified data gaps, and support the selection of appropriate remedial alternatives. Secondary objectives include better defining water movement through the vadose zone. The primary uses of the data gathered during lysimeter and perched water sampling are to identify contaminants, concentration trends, and their movement in the vadose zone.

Samples collected from the vadose zone are of limited volume due to arid conditions at the INL Site. Sample volumes collected can range from 100 to about 1,000 mL for some lysimeters and may be as little as a few drops to a few milliliters in others. Because of the limited volumes, OU 7-13/14 has established analytical priorities for the lysimeter and perched water samples. The priorities are periodically reviewed and updated based on emerging issues and needs. In April 2005, the analytical priorities were once again evaluated and modified to maximize usability of the data for the remedial investigation/feasibility study. Priorities were established by weighing the contaminants (1) risk, (2) inventoried quantity of disposed material, (3) analytical detectability, (4) detection frequency, and (5) value to fate and transport modeling. The following evaluation documents the process used for selecting and prioritizing analytes.

2.1 Data Needs

Data Quality Objectives (DQOs) are discussed in context of the DQO process as defined by EPA in *Guidance for the Data Quality Objectives Process* (EPA 2000). This process was developed by EPA to ensure that the type, quantity, and quality of data used in decision-making is appropriate for the intended application. Data quality objectives are qualitative and quantitative statements derived from the first six steps of the EPA DQO process that:

- Clarify the study objective
- Define the most appropriate type of data to collect to meet project needs
- Determine the most appropriate conditions from which to collect the data
- Specify tolerable limits on decision errors that will be used as a basis for establishing the quantity and quality of data needed for decision-making.

The data gaps, study boundaries, and decision inputs and rules are discussed in the following sections.

2.1.1 Problem Statement

Radioactive and hazardous waste has been disposed of in unlined pits, soil vaults, and trenches in the SDA with the potential to leach into the vadose zone and ultimately impact the Snake River Plain Aquifer. Data is needed to:

- Assess the nature and extent of contamination associated with OU 7-13/14
- Assess migration of magnesium chloride in the vadose zone

- Provide data on tracers/potential calibration targets (chromium and chloride)
- Contribute to the understanding of geochemistry in the soil moisture to assess migration potential.

2.1.2 Decision Statement

This step defines the questions that the study will attempt to resolve and to identify the alternative actions that may be taken based on the outcome of the study. The defined questions and their corresponding alternative actions will then be joined to form decision statements. The principal study questions (PSQs) that the study will attempt to resolve are:

- PSQ #1—Do the contaminant concentrations in the soil moisture and perched water exceed EPA drinking water MCLs (40 CFR 141), background concentrations determined outside the SDA, or RBCs for the contaminant?
- PSQ #2—For contaminants present in the soil moisture and perched water, is a trend apparent that indicates that EPA MCLs contaminant RBCs may be exceeded at some point in the future?
- PSQ #2—Do the trends of the contaminant concentrations present in the soil moisture and perched water indicate that contaminant migration is occurring?
- PSQ #4—If contaminants are present in the soil moisture and perched water, what are the possible sources of contamination?

The PSQ gives the following decision statement: Determine the presence of contaminants in the perched water and soil moisture. To address this decision, the project will collect and analyze samples for the target contaminants as identified in Table 2-1.

Table 2-1. Routine analyses.^a

| Analysis Priority | Preservative | CRDLs (pCi/L or mg/L) ^b | Sample Volume (mL) | Justification |
|-----------------------------|--------------------------|---------------------------------------|--------------------------|---|
| Gamma emitters/Tc-99 | HNO ₃ to pH<2 | <200 (gamma) <15 (Tc-99) | 50 | Gamma spectroscopy is a nondestructive analysis that provides data on several contaminants of concern; Tc-99 is a contaminant of concern, high-risk driver and highly mobile ($K_d \sim 0$ mL/g). Tc-99 is detected in the vadose zone (core, soil moisture, and perched water samples). Tc-99 detected at two locations with increasing concentrations. |
| Uranium/plutonium/ameridium | HNO ₃ to pH<2 | <2 for each | 50 | Contaminants of concern, risk drivers. Uranium consistently detected above RBCs and EPA MCLs at various locations. Plutonium is a contaminant of special consideration. |

Table 2-1. (continued).

| Analysis Priority | Preservative | CRDLs (pCi/L or mg/L) ^b | Sample Volume (mL) | Justification |
|-------------------|-----------------------------|---------------------------------------|--------------------------|--|
| C-14 | None | <50 | 50 | High-risk driver, highly mobile ($K_d \sim 5$ mL/g). Detected in vadose zone (perched water and soil moisture samples). |
| Anions | 4°C | 0.5 | 25 | Nitrate is a contaminant of concern; chloride is a component of magnesium chloride, which was applied to roads and serves as a water tracer. |
| Metals | HNO ₃ to pH<2 | See Table 2-2 | 25 | Contract Laboratory Program to reduce sample volume. Chromium is a potential model calibration target. |
| H-3 | None | <250 | 50 | Low-risk driver. Detected in vadose zone (perched water and soil moisture samples) at isolated locations. |
| Cl-36 | HNO ₃ to pH<2 | 100 | 50 | Not well characterized in the vadose zone; associated with beryllium blocks; seldom detected. |
| I-129 | None | <40 | 50 | High-risk driver, highly mobile ($K_d \sim 0.1$). Intermittently detected in vadose zone (soil moisture) at levels >MCL. |
| Np-237 | HNO ₃ to pH<2 | <2 | 50 | High-risk driver, highly mobile ($K_d \sim 8$). Not detected in vadose zone but detected in waste zone. |

a. Priorities for excess sample volume will be negotiated for each round based on emerging needs.

b. Detection limits (required detection limits [RDLs]) are as low as reasonably achievable, considering the extremely limited sample volume.

c. Lower detection limits have been achieved with less volume.

CRDL = contract-required detection limit

EPA = U.S. Environmental Protection Agency

MCL = maximum contaminant level

RBC = risk-based concentration

2.1.3 Decision Inputs

The following inputs are needed for the decisions in Section 2.1.2:

- List of COCs for OU 7-13/14 based on inventory records and historical data
- Analytes that are not COCs
- Analysis priorities as indicated by SDA source term, contaminant mobility, previous detections, and risk, as defined by modeling in the *Ancillary Basis For Risk Analysis* (Holdren et al. 2002), the *RWMC Low-Level Waste Radiological Performance Assessment for Calendar Year 2000* (Case et al. 2000), and the *RWMC Low-Level Waste Radiological Composite Analysis* (McCarthy et al. 2000).
- Assessment of chemical and radionuclide data from soil moisture and perched water.

2.1.4 Study Boundaries

The objective of this step is to identify the population of interest, define the applicable spatial and temporal boundaries, and identify any practical constraints (hindrances or obstacles) that must be taken into consideration in the sampling design.

This study will focus on the perched water and soil moisture collected in and around the RWMC for evaluation of the potential migration of contaminants. Sampling will occur quarterly. For OU 7-13/14 lysimeter and perched water monitoring, the primary constraint to be considered is whether water is present in the selected perched water wells, the limited volume of water that may be collected, and analytical priorities that may be applied to limited sample volume available.

Deviations from the analytical priorities for routine quarterly sampling may be needed to address an emerging issue or trend development in sampling data. A deviation in analytical priorities may be made with Agency concurrence. If the need for deviations becomes routine, then the FSP will be revised to address the change in analytical priorities and the Agencies will be notified.

2.1.5 Decision Rule

The objective of this step is to specify the parameter of interest (e.g., mean, 95% upper confidence level) that will be used for comparison against the MCL. Data are compared against the local soil moisture background values, EPA MCLs, and RBCs for the contaminant.

If the concentration for a contaminant in soil moisture or perched water sample exceeds the EPA MCL or RBC for a given contaminant, the detection is reported to the Agencies in the quarterly soil moisture and perched water monitoring report. The local soil moisture background value for the contaminant is also reported for comparison.

If the concentration for a contaminant in soil moisture or perched water sample exceeds the local soil moisture background value for a given contaminant, the detection is reported to the Agencies in the quarterly soil moisture and perched water monitoring report. The applicable EPA MCL or RBC is also reported for comparison.

If the statistical trend for any contaminant in soil moisture or perched water indicates that concentrations are increasing, that information is reported to the Agencies in the quarterly soil moisture

and perched water monitoring report. Conversely, if the trend indicates that contaminant concentrations are decreasing, then the analysis priority for the contaminant may be modified through discussions with the Agencies.

2.1.6 Sampling Design and Associated Decision Error

Because analytical data can only estimate the true condition of the site under investigation, decisions that are made based on measurement data could potentially be in error (i.e., decision error). For this reason, this DQO step determines which decision statements (if any) require a statistically based sample design. The purpose of determining the decision error limits is to specify the decision-maker's tolerable limits on decision errors, which are used to establish performance goals for the data collection design.

Tolerable error limits assist in the development of sampling designs to ensure that the spatial variability and sampling frequency are within specified limits. However, the sampling design for the soil moisture and perched water monitoring is determined by the active lysimeters and perched wells locations. Therefore, error limits are not used to determine sampling locations or frequency.

For the comparison of analytical data to EPA MCLs, RBCs, and local soil moisture background values, there is no need to define the "gray region" or the tolerable limits on the decision error since these only apply to statistical designs.

2.1.7 Optimize the Design

This step identifies the most resource-effective data collection design that satisfies all of the data quality requirements.

2.1.7.1 Lysimeter and Perched Water Monitoring. There will be four sampling rounds per year with consistent analytical priorities. Samples will be sent to laboratories for analysis with full quality assurance/quality control (QA/QC) protocols. Table 2-2 lists detection limits for cations (metals) using the limited sample volume expected.

Occasionally, a lysimeter will yield more than enough sample volume to cover analysis requirements. Use of excess sample volume will be determined routinely based on emerging needs.

Table 2-2. Detection limits for cations (25-mL sample) using Contract Laboratory Program.

| Analyte | RDL (µg/L) | Method | Analyte | CRDL (µg/L) | Method |
|-----------|-----------------|--------|-----------|----------------|--------|
| Aluminum | 200 | ICP | Zinc | 20 | ICP |
| Antimony | 60 | ICP | Lead | 3 | GFAA |
| Arsenic | 10 | GFAA | Magnesium | 5,000 | ICP |
| Barium | 200 | ICP | Manganese | 15 | ICP |
| Beryllium | 5 | ICP | Nickel | 40 | ICP |
| Cadmium | 5 | ICP | Potassium | 5,000 | ICP |
| Calcium | 5,000 | ICP | Selenium | 5 | GFAA |
| Chromium | 10 ^a | ICP | Silver | 10 | ICP |
| Cobalt | 50 | ICP | Sodium | 5,000 | ICP |
| Copper | 25 | ICP | Thallium | 10 | GFAA |
| Iron | 100 | ICP | Vanadium | 50 | ICP |

a. Detection limit for chromium may be as low as 2 µg/L.

CRDL = contract-required detection limit based on a minimum sample volume of 25 mL

GFAA = graphite furnace atomic adsorption

ICP = inductively coupled plasma

RDL = required detection limit

2.1.7.2 Control Charting the Data. Combined Shewhart-CUSUM control charts is one of the EPA-recommended statistical approaches for intra-well data comparisons, especially when the analytes or radionuclides being monitored are also constituents of groundwater background. The control chart is a combination of the Shewhart Control Chart (Shewhart 1931), developed to discover large deviations from the expected level, and the CUSUM Control Chart (Page 1954), developed to discover gradual changes over time.

The combined Shewhart-CUSUM control chart compares sequential measurements in time against established control limits. The control limits are based on observed historical ranges of variability in measured contaminant concentrations in groundwater wells. Results above control limits are declared a statistical exceedance and will require some action on the part of the data evaluator. The combined Shewhart-CUSUM control chart has two process control limits. The Shewhart component monitors the process one sample at a time to detect large, sudden departures from the baseline concentration and range of variability. The CUSUM component monitors the cumulative process to detect gradual increases from baseline concentration and range of variability over time.

The Shewhart control limit is defined to be

$$SCL = \bar{x} + zs, \quad (1)$$

where \bar{x} is the baseline mean, s is the baseline standard deviation, and z is chosen to provide the desired false-positive rate. The value for z specified by the U.S. EPA (1992a and 1992b) based on studies by Starks (1989), is 4.5. So a sample result 4.5 standard deviations larger than the baseline mean is declared a statistical exceedance.

The CUSUM control chart statistic for time i is defined to be

$$S_i = \max \left\{ 0, \frac{x_i - \bar{x}}{s} - k + S_{i-1} \right\}, \quad (2)$$

where k is the displacement parameter (the minimum number of standard deviations change between one result to the next that is added to the CUSUM statistic). The CUSUM statistic (S_i) is compared to the control limit h , which is the number of standard deviations the process may shift over time before considered out of control. The U.S. EPA (1992a and 1992b), based on studies by Starks (1989), recommends values of $k = 1$ and $h = 5$. Thus, positive increases of less than one standard deviation ($k = 1$) from the baseline mean are not added to the CUSUM statistic. This is a minimal variability in results and should not be accumulated because reaching the limit would be inevitable, even without contamination. A cumulative increase of $h = 5$ standard deviations results in a statistical exceedance.

The control limits in this discussion are only proposed values. The actual control limits will be developed by OU 7-13/14 and applied as guidelines to evaluate routine groundwater monitoring data. The developed control limits will be based on the variability of the historical data and defining practical baseline concentrations for each well and analyte. Monitoring data acquired to date varies from well to well and analyte to analyte, and from sampling event to sampling event; therefore, establishing proper control limits will initially require the expertise of a statistician. Shewhart-CUSUM control charts are currently used by OU 7-13/14; however, accurate control limits have yet to be established. Therefore, at this time, the charts only provide a fairly sensitive statistical tool to evaluate concentration trends.

The advantages of the combined control chart are that it is graphically displayed and easy to read, the method is somewhat robust to the assumption of normality (Starks 1989), and it can detect both sudden large concentration increases as well as gradual concentration increases over time. Gibbons (1999) demonstrates that the combined control chart has lower false-negative rates than parametric prediction limits.

2.2 Quality Assurance Objectives for Measurement

The quality assurance objectives for measurement will meet or surpass the minimum requirements for data quality indicators established in the QAPjP (DOE-ID 2004). The QAPjP provides minimum requirements for the following measurement quality indicators: precision, accuracy, representativeness, completeness, and comparability. Precision, accuracy, and completeness will be calculated in accordance with the QAPjP.

2.2.1 Precision

Precision is a measure of the reproducibility of measurements under a given set of conditions. In the field, precision is affected by sample collection procedures and the unknown and potentially extreme heterogeneity of the buried waste. Overall precision (i.e., field and laboratory) evaluations can be supported by collecting duplicate samples.

Laboratory precision will be based on the use of laboratory-generated duplicate samples or matrix spike and matrix spike duplicate samples. Evaluation of laboratory precision will be performed during the process of method data validation.

Field precision will be based upon the analysis of collected field duplicate or split samples. For samples collected for laboratory analyses, a field duplicate will be collected at a minimum frequency of 1 in 20 environmental samples.

2.2.2 Accuracy

Accuracy is a measure of bias in a measurement system. Bias is the systematic or persistent distortion of a measurement process that causes errors in one direction. Laboratory accuracy is demonstrated using laboratory control samples, blind QC samples, and matrix spikes. Evaluation of laboratory accuracy will be performed during the method data validation process. Sample preservation and handling, field contamination, and the sample size and matrix affect overall accuracy. By evaluating results from field blanks, trip blanks, and equipment rinsates, false positives or high-biased sample results will be assessed. The representativeness of the sample (discussed below) is also a factor in the overall accuracy of the result.

Field accuracy will only be determined for samples collected for laboratory analysis. The field screening instrumentation can only analyze the soils and is not set up for the analysis of water samples. Therefore, accuracy of field instrumentation will be ensured through the use of appropriate calibration procedures and standards.

2.2.3 Representativeness

Representativeness is a qualitative parameter that expresses the degree to which the sampling and analysis data accurately and precisely represent a characteristic of a population, the parameter variations at a sampling point, or an environmental condition. Representativeness will be evaluated by determining whether measurements are made and physical samples are collected in such a manner that the resulting data appropriately measure the media and phenomenon studied. The comparison of all field and laboratory analytical data sets obtained throughout this remedial action will be used to ensure representativeness.

2.2.4 Detection Limits

Detection limits will meet or exceed the risk-based or decision-based concentrations for the contaminants of concern. Detection limits will be as specified in the Sample and Analysis Management (SAM) Analytical Services Statement of Work (ER-SOW-394), project-specific Task Order Statements of Work, and as described in the QAPjP (DOE-ID 2004).

2.2.5 Completeness

Completeness is a measure of the quantity of usable data collected during the field sampling activities. The QAPjP (DOE-ID 2004) requires that an overall completeness goal of 90% be achieved for noncritical samples. If critical parameters or samples are identified, a 100% completeness goal is specified. Critical data points are those sample locations or parameters for which valid data must be obtained in order for the sampling event to be considered complete. Given that this is a monitoring project, all field screening and laboratory data will be considered noncritical with a completeness goal of 90%.

2.2.6 Comparability

Comparability is a qualitative characteristic that refers to the confidence with which one data set can be compared to another. At a minimum, comparable data must be obtained using unbiased sampling

designs. If sampling designs are not unbiased, the reasons for selecting another design should be well documented. Data comparability will be assessed through the comparison of all data sets collected during this study for the following parameters:

- Data sets will contain the same variables of interest
- Units will be expressed in common metrics
- Similar analytical procedures and QA will be used to collect data
- Time of measurements of variables will be similar
- Measuring devices will have similar detection limits
- Samples within data sets will be selected in a similar manner
- The number of observations will be of the same order of magnitude.

2.2.7 Data Validation

Method data validation is the process whereby analytical data are reviewed against set criteria to ensure that the results conform to the requirements of the analytical method and any other specified requirements.

All laboratory-generated analytical data will be validated to Level “B” as described in Guide (GDE) -7003, “Levels of Analytical Method Data Validation.” Field-generated data will not be validated. Quality of the field-generated data will be ensured through adherence to established operating procedures and use of equipment calibration, as appropriate.

3. LYSIMETER AND PERCHED WATER SAMPLING LOCATIONS AND INSTALLATION INFORMATION

Lysimeter and perched water wells will be sampled routinely in accordance with the guidelines in Section 5 and applicable technical procedures. The current list of active lysimeters is provided in Table 3-1, and the locations of lysimeters and perched water wells are provided in Figure 3-1. Additional information about the lysimeters, including their construction and original objectives, is provided in the following discussion.

Table 3-1. Suction lysimeters installed at the RWMC.

| Lysimeter | Well | Date Installed | Lysimeter Depth (ft) | Cup Type |
|-----------|-------------------|--------------------|-------------------------|----------|
| L01 | W02 ^a | June 14, 1985 | 14.0 | Ceramic |
| L02 | W03 | June 17, 1985 | 10.5 | Ceramic |
| L03 | W04 | June 19, 1985 | 24.5 | Ceramic |
| L04 | W04 | June 19, 1985 | 15.4 | Ceramic |
| L05 | W04 | June 19, 1985 | 6.2 | Ceramic |
| L06 | W20 | June 28, 1985 | 6.7 | Teflon |
| L07 | W23 | June 28, 1985 | 18.8 | Teflon |
| L08 | W23 | June 28, 1985 | 11.8 | Ceramic |
| L09 | W23 | June 28, 1985 | 7.7 | Ceramic |
| L10 | T23 | July 2, 1985 | 19.0 | Teflon |
| L11 | C02 | July 3, 1985 | 4.3 | Teflon |
| L12 | W08 | July 9, 1985 | 22.1 | Ceramic |
| L13 | W08 | July 9, 1985 | 11.3 | Ceramic |
| L14 | W08 | July 9, 1985 | 6.2 | Ceramic |
| L15 | PA01 ^b | July 11, 1985 | 14.3 | Ceramic |
| L16 | PA02 ^b | July 11, 1985 | 8.7 | Ceramic |
| L17 | TH02 | June 7, 1985 | 6.0 | Ceramic |
| L18 | TH04 | April 23, 1985 | 4.0 | Ceramic |
| L19 | C01 | August 6, 1986 | 17.7 | Ceramic |
| L20 | C01 | August 6, 1986 | 7.4 | Ceramic |
| L21 | TH05 | September 8, 1986 | 15.2 | Ceramic |
| L22 | TH05 | September 8, 1986 | 5.9 | Ceramic |
| L23 | W09 | September 17, 1986 | 14.8 | Ceramic |
| L24 | W05 | September 22, 1986 | 15.9 | Ceramic |
| L25 | W05 | September 22, 1986 | 10.0 | Ceramic |

Table 3-1. (continued).

| Lysimeter | Well | Date Installed | Lysimeter Depth (ft) | Cup Type |
|-----------|-------------------|--------------------|-------------------------|-----------------|
| L26 | W05 | September 22, 1986 | 6.7 | Ceramic |
| L27 | W06 | September 23, 1986 | 11.8 | Ceramic |
| L28 | W25 | September 24, 1986 | 15.5 | Ceramic |
| L29 | W13 | September 20, 1986 | 14.0 | Ceramic |
| L30 | W13 | September 28, 1986 | 6.7 | Ceramic |
| L31 | W17 | September 29, 1986 | 19.6 | Ceramic |
| L32 | W17 | September 29, 1986 | 10.9 | Ceramic |
| L33 | PA03 ^b | December 1994 | 10.0 | Ceramic |
| L34 | PA04 ^b | December 1994 | ~27 | Ceramic |
| L35 | 98-1 | February 2, 1998 | 16.5 | Ceramic |
| L36 | 98-2 | January 29, 1998 | 9.0 | Ceramic |
| L37 | 98-3 | February 4, 1998 | 22.5 | Ceramic |
| L38 | 98-4 | February 3, 1998 | 17.0 | Ceramic |
| L39 | 98-5 | February 2, 1998 | 10.5 | Ceramic |
| L40 | LYS-1 | 1994 | 19.7 | Ceramic |
| L41 | LYS-1 | 1994 | 6.6 | Ceramic |
| DL01 | D06 | September 12, 1986 | 88.0 | Ceramic |
| DL02 | D06 | September 12, 1986 | 44.0 | Ceramic |
| DL03 | TW1 | June 25, 1987 | 226.9 | Ceramic |
| DL04 | TW1 | June 25, 1987 | 101.7 | Ceramic |
| DL05 | D15 | September 15, 1987 | 222.9 | Ceramic |
| DL06 | D15 | September 15, 1987 | 97.9 | Ceramic |
| DL07 | D15 | November 4, 1987 | 32.2 | Ceramic |
| DL08 | I-1D | ~November 1999 | 224 | Stainless steel |
| DL09 | I-1S | ~November 1999 | 101 | Stainless steel |
| DL10 | I-2D | ~November 1999 | 196 | Stainless steel |
| DL11 | I-2S | ~November 1999 | 92 | Stainless steel |
| DL12 | I-3D | ~November 1999 | 228 | Stainless steel |
| DL13 | I-3S | ~November 1999 | 93 | Stainless steel |
| DL14 | I-4D | ~January 2000 | 226.5 | Stainless steel |
| DL15 | I-4S | ~January 2000 | 97 | Stainless steel |

Table 3-1. (continued).

| Lysimeter | Well | Date Installed | Lysimeter Depth (ft) | Cup Type |
|-----------|----------|-------------------|-------------------------|-----------------|
| DL16 | I-5S | ~March 2000 | 98.7 | Stainless steel |
| DL17 | O-1 | December 16, 1999 | 228 | Stainless steel |
| DL18 | O-1 | December 16, 1999 | 96 | Stainless steel |
| DL19 | O-2 | January 12, 2000 | 240 | Stainless steel |
| DL20 | O-2 | January 12, 2000 | 106 | Stainless steel |
| DL21 | O-3 | November 1999 | 219 | Stainless steel |
| DL22 | O-3 | November 1999 | 87 | Stainless steel |
| DL23 | O-4 | January 4, 2000 | 225 | Stainless steel |
| DL24 | O-4 | January 4, 2000 | 108.5 | Stainless steel |
| DL25 | O-5 | January 12, 2000 | 104 | Stainless steel |
| DL26 | O-6 | November 1999 | 225 | Stainless steel |
| DL27 | O-7 | November 1999 | 240 | Stainless steel |
| DL28 | O-7 | November 1999 | 119 | Stainless steel |
| DL29 | O-8 | ~November 1999 | 228 | Stainless steel |
| DL30 | IE3 | March 2003 | 225 | Stainless steel |
| DL31 | DE3 | March 2003 | 345 | Stainless steel |
| DL32 | IE4 | March 2003 | 223 | Stainless steel |
| DL33 | DE4 | March 2003 | 463 | Stainless steel |
| DL34 | IE6 | December 2002 | 215 | Stainless steel |
| DL35 | IE7 | December 2002 | 231 | Stainless steel |
| DL36 | DE7 | February 2003 | 377 | Stainless steel |
| DL37 | DE7 | February 2003 | 413 | Stainless steel |
| DL38 | IE8 | February 2003 | 224 | Stainless steel |
| DL39 | DE8 | February 2003 | 393 | Stainless steel |
| DL40 | S1898 | Spring 2004 | 225 | Stainless Steel |
| DL42 | RWMC2005 | Spring 2004 | 8.9 | Stainless Steel |
| DL43 | RWMC2006 | Spring 2004 | 235 | Stainless Steel |
| DL44 | RWMC2006 | Spring 2004 | 182 | Stainless Steel |
| DL45 | RWMC2006 | Spring 2004 | 105 | Stainless Steel |
| DL46 | RWMC2006 | Spring 2004 | 75 | Stainless Steel |
| DL47 | RWMC2006 | Spring 2004 | 11 | Stainless Steel |
| DL48 | RWMC2004 | Spring 2004 | 240 | Stainless Steel |

Table 3-1. (continued).

| Lysimeter | Well | Date Installed | Lysimeter Depth (ft) | Cup Type |
|-------------------|----------|----------------|-------------------------|-----------------|
| DL49 | RWMC2004 | Spring 2004 | 101 | Stainless Steel |
| DL50 | RWMC2004 | Spring 2004 | 74 | Stainless Steel |
| DL51 ^c | RWMC2004 | Spring 2004 | 16.5 | Stainless Steel |
| DL52 | RWMC1935 | Summer 2004 | 383 | Stainless Steel |
| DL53 | RWMC1935 | Summer 2004 | 355 | Stainless Steel |
| DL54 | RWMC1935 | Summer 2004 | 335.5 | Stainless Steel |
| DL55 | RWMC1935 | Summer 2004 | 280 | Stainless Steel |
| DL56 | RWMC1935 | Summer 2004 | 248 | Stainless Steel |
| DL57 | RWMC1935 | Summer 2004 | 236 | Stainless Steel |
| DL58 | RWMC1935 | Summer 2004 | 217.5 | Stainless Steel |
| DL59 | RWMC1935 | Summer 2004 | 134 | Stainless Steel |
| DL60 | RWMC1935 | Summer 2004 | 96 | Stainless Steel |
| DL61 | RWMC1936 | Summer 2004 | 371 | Stainless Steel |
| DL62 | RWMC1936 | Summer 2004 | 342 | Stainless Steel |
| DL63 | RWMC1936 | Summer 2004 | 302 | Stainless Steel |
| DL64 | RWMC1936 | Summer 2004 | 270 | Stainless Steel |
| DL65 | RWMC1936 | Summer 2004 | 233 | Stainless Steel |
| DL66 | RWMC1936 | Summer 2004 | 182 | Stainless Steel |
| DL67 | RWMC1936 | Summer 2004 | 143 | Stainless Steel |
| DL68 | RWMC1936 | Summer 2004 | 113 | Stainless Steel |
| DL69 | RWMC1936 | Summer 2004 | 103 | Stainless Steel |
| DL70 | RWMC1936 | Summer 2004 | 30 | Stainless Steel |



Lysimeter destroyed by Pit 9 activities.



Lysimeter yielded sample in the past but is no longer in the sampling network.



Lysimeter is in the current sampling network.



Lysimeter has never yielded a sample.



Lysimeter has been abandoned.

- a. Lysimeters L01 and W02 were inactivated after 1993, because they obstructed the construction phase of Pit 9 remediation activities.
- b. Boreholes PA01 and PA02 were located in surficial sediment a couple of feet off the edge of the Pad A asphalt pad. The lithologic log for borehole PA03 does not indicate augering through the asphalt pad. The lysimeter in borehole PA04 was installed horizontally under the asphalt pad.
- c. Lysimeter port is installed, but a suction lysimeter cannot enter the port because of obstruction or bend in port.

Figure 3-1. Locations of lysimeters and perched water wells in the SDA.

Monitoring of contaminants in soil moisture began with the installation of lysimeters by the Subsurface Investigation Program in 1985. The first lysimeters were installed to characterize solution chemistry and to define radionuclide migration in the vadose zone (Hubbell et al. 1985). Shallow lysimeters were installed in auger holes with silica flour slurry surrounding the lysimeter cup. A 2- to 3-in. layer of bentonite was placed on top of the silica flour as a moisture seal, and native sediments were used to backfill the borehole. Deep lysimeters in the B-C and C-D interbeds were installed in silica flour slurry, and bentonite was used to seal between instrument installations in the same borehole. From 1985 through 1987, 32 suction lysimeters were installed in surficial sediments in and around the RWMC, and seven deep lysimeters were installed in sedimentary interbeds (Hubbell et al. 1985, 1987; Laney et al. 1988).

As part of remediation and monitoring activities for Pad A (Parsons 1995a, 1995b), two lysimeters were installed in December 1994. Lysimeter L33 was installed at a depth of 3 m (10 ft) below land surface on the north side of Pad A in borehole PA03. Pad A is an aboveground disposal area located on an asphalt pad. However, well logs indicate that drillers did not encounter the asphalt pad when augering borehole PA03; therefore, either the asphalt pad does not extend as far as borehole PA03, or the lysimeter is located in cover material above the asphalt pad. Lysimeter L34 was installed in a horizontal borehole under the asphalt at Pad A in borehole PA04. Lysimeter L34 is located near the center of Pad A, approximately 50 m (165 ft) northeast of the borehole PA04 wellhead. Both lysimeters were installed in silica flour, and bentonite was used to seal the silica flour layer.

Five lysimeters, L35 through L39, were installed in surficial sediments in the SDA in 1998 to assess magnesium chloride migration in soil at the SDA (see Table 3-1). Magnesium chloride was applied to SDA roads to suppress dust in 1984, in 1985, and in the early 1990s, and the chloride might contribute to the corrosion of buried waste containers (Hull and Bishop 2003). Each of the lysimeters was installed as close as possible to the sediment/basalt interface. A soil slurry was placed around the porous ceramic cup, native soil was used to backfill the borehole, and a 0.3-m (1-ft) layer of bentonite was placed 0.6 m (2 ft) above the instrument to serve as a barrier to downhole water movement.

Suction lysimeters L40 and L41 were installed in 1994 to collect water samples near buried beryllium blocks near the west end of Soil Vault Row (SVR)-20. Lysimeter cups were placed in native fill material with a layer of sand above and below the lysimeter, and the borehole was backfilled with bentonite. Several attempts were made to collect a sample from L40, but a sufficient vacuum to collect a sample could not be maintained. The deeper lysimeter, L41, yielded enough sample volume to analyze for chloride, C-14, and tritium (Ritter and McElroy 1999).

From November 1999 through March 2000, 22 deep lysimeters, DL08 through DL29, were installed inside and outside the SDA (Dooley and Higgs 2003) (see Table 3-1). The porous cups on these lysimeters are stainless steel with -600 cm of water air entry pressure. Installation was similar to the procedure described above with silica flour slurry between layers of bentonite. Between December 2002 and March 2003, 10 deep lysimeters, DL30 through DL39, were installed in nine wells inside the SDA in a manner similar to that described above. The stainless-steel porous cups of these lysimeters were saturated with distilled water before installation, which needs to be considered when evaluating data from the first round of samples collected from these lysimeters.

Eighteen lysimeters were located in the waste zone at the beginning of FY 2004, and their locations were chosen based on a need to investigate specific focus areas. The waste zone lysimeters were placed from 1.5 to about 9 m (5 to about 30 ft) deep, and are in or just below the target waste, at the point of waste and underburden contact, or at the point of contact with the underlying basalt. Six waste zone lysimeters were abandoned in 2004 because they had not produced soil moisture samples since 2001.

In 2004, three new wells were installed in the SDA, and two were installed outside the SDA. All five wells were instrumented with lysimeters. The depths of the newly installed lysimeters vary from 2.7 to 117 m (8.9 to 383 ft). Three lysimeter wells (R2004, R2005, and R2006) were installed on the east side of the SDA, with three lysimeters located in the 0–11 m (0–35 ft) depth interval, four in the 11–43 m (35–140 ft) interval, and three at depths greater than 43 m (140 ft). Also in 2004, Lysimeter Wells RWMC-1935 and RWMC-1936 were installed outside the SDA in the western and southwestern region of the RWMC to monitor the influence from the spreading areas and provide supplemental background monitoring for the vadose zone. These two lysimeter wells have one lysimeter located in the 0–11-m (0–35-ft) depth interval, four in the 11–43-m (35–140-ft) interval, and 14 at depths greater than 43 m (140 ft).

The lysimeter and perched water wells will be sampled routinely for the analyses specified in Section 2. All sampling will be conducted using the guidelines provided in Section 5. Table 3-1 identifies the lysimeters installed and sampled in and around the SDA.

4. SAMPLE IDENTIFICATION

A systematic 10-character sample identification code will be used to uniquely identify all samples. The uniqueness of the number is required to maintain consistency and ensure that no two samples are assigned the same identification code. The sample numbers are assigned by Sampling and Analysis Management (SAM) personnel. The SAM database is used to ensure the uniqueness of sample identification.

A SAP table format was developed to simplify the presentation of the sampling scheme for project personnel. The following subsections describe the information recorded in the SAP table and database. The current SAP table for lysimeter and perched water monitoring is provided in Appendix A. The field descriptions are described below.

4.1 Sample Description Fields

The sample description fields contain information about individual sample characteristics.

4.1.1 Sampling Activity

The sampling activity field contains the first six characters of the assigned sample number. The sample number in its entirety will be used to link information from other sources (e.g., field data, analytical data) to the information in the SAP table for data reporting, sample tracking, and completeness reporting. The analytical laboratory will also use the sample number to track and report analytical results.

4.1.2 Sample Type

Data in this field will be selected from the following:

REG for a regular sample

QC for a quality control sample.

4.1.3 Sample Matrix

This field describes the sample media/matrix, typically GROUND WATER or WATER for certain QC samples.

4.1.4 Collection Type

This field is typically populated with GRAB or other codes for certain types of QC samples (e.g., FBLK for field blank).

4.1.5 Planned Date

This date is related to the approximate sample collection start date.

4.2 Sample Location Fields

This group of fields describes the location of the sample origin.

4.2.1 Area

This field identifies the general sample collection area, which is RWMC.

4.2.2 Location

This field contains the name of the well and lysimeter from which the sample was taken.

4.2.3 Type of Location

This field supplies descriptive information concerning the type of sample location, typically LYSIMETER (for lysimeters) or PERCHED WATER (for perched water samples, such as those collected from USGS-092).

4.2.4 Depth

The depth field contains the depth at which the respective sample was collected.

4.3 Analysis Types

4.3.1 AT1–AT20

These fields contain analysis code designations. Specific descriptions for these analysis codes are provided at the bottom of the SAP table (see Appendix A).

5. SAMPLING EQUIPMENT AND PROCEDURES

Field sampling methods and field analyses that may be performed are discussed in detail in Technical Procedure (TPR)-1641, “Collection of Vadose Zone Water Samples at the RWMC.”

5.1 Sample Collection

5.1.1 Site Preparation

All required documentation and safety equipment will be assembled at the well sampling site, including personal protective equipment; adequate sample bottles, lids, and labels; an argon gas bottle and regulator; power source (generator); and a vacuum pump and gauge.

Before sampling, all sampling personnel are responsible for reading the FSP, the corresponding health and safety plan, and TPR-1641 and for becoming familiar with the analytical requirements for that sampling round as stated in the SAP table. The field team leader (FTL) will perform a daily site briefing to discuss potential hazards and ensure that all personnel have the required training. The FTL or assigned team member will maintain all documents and field data. This should be noted in the appropriate logbook.

5.1.2 Applying Vacuum to Lysimeters

Sampling personnel will follow the guidance for applying the vacuum to the lysimeters as outlined in TPR-1641. The vacuum should be left on the lysimeter for 7 to 14 days. Sampling personnel should check the status of the vacuums periodically and apply additional vacuum as necessary.

5.1.3 Collecting Lysimeter Water Sample

After the vacuum has been placed on the lysimeter for 7 to 14 days, sampling personnel will collect any soil moisture that has accumulated in the lysimeter. The water in the lysimeter should be removed by pressurizing the system with argon gas, steadily increasing the pressure of the argon through the air line until the pressure exceeds the weight of the water in the lysimeter. This will force the water to the surface. The water is collected in prepared bottles for shipment to laboratories.

5.1.4 Collecting Perched Water Samples with a Bailer

Wells containing perched water will be sampled with a suction bailer in accordance with TPR-1641.

5.2 Field Analysis

Analysis may be performed in the field for constituents sensitive to change as a function of time after sample collection. The analytical and instrument operational instructions are specified in operating manuals provided by the vendors for the equipment selected for the project. Analyses that may be performed in the field include alkalinity and pH.

5.2.1 Alkalinity

A HACH digital titrator Model 16900 measures alkalinity in accordance with HACH digital titrator Method 8203. Indicator powders are added, and the sample is titrated with sulfuric acid to colorimetric end points corresponding to a specific pH. The method is designed to measure alkalinity in the range of 10 to 4,000 mg/L. The analytical procedure is given in the manufacturer’s operating manual (HACH 2000). This procedure covers quality assurance requirements and limitations of the method. The test kit and method may be substituted with an equivalent test kit/method in the future without the need to revise this plan.

5.2.2 pH

A Thermo Orion Model 230 Aplus meter measures pH in the field. The analytical method, including all calibration procedures, is contained in the unit's instruction manual (Thermo Orion 2001). The test kit and method may be substituted with an equivalent test kit/method in the future without the need to revise this plan.

6. SAMPLE HANDLING, PACKAGING, AND SHIPPING

After lysimeter samples are collected, the gloved sampling technician will wipe the bottles to remove any residual water and will place them in the custody of the designated sample custodian. The sample custodian/shipper is responsible for ensuring that clear tape is placed over bottle labels, lids are checked for tightness, parafilm is placed around lids, and samples are bagged and properly packaged before shipment. Additional information is found in MCP-1193, "Handling and Shipping Samples for ER and D&D&D Projects."

Lysimeter samples have been collected periodically from the RWMC wells since the late 1980s. The laboratory results from all of these samples show that the samples are well below the U.S. Department of Transportation classification of radioactive material. Based on the process knowledge from the previous monitoring results, samples taken from sampling locations included in this plan will not require a field sample radiation screen (gamma screen) or an off-site laboratory shipping screen.

Samples will be transported in accordance with the regulations issued by the Department of Transportation (49 CFR 171 through 178) and EPA sample handling, packaging, and shipping methods (40 CFR 261). Additional information is found in MCP-1193.

7. DOCUMENTATION

The FTL or designee is responsible for controlling and maintaining all field documents and records and ensuring that all required documents are submitted to the SAM record coordinator.

Field changes will be implemented by the FTL in accordance with MCP-135, “Creating, Modifying and Canceling Procedures and other DMCS-Controlled Documents.” All entries will be made in permanent, nonsmearable black ink. All errors will be corrected by drawing a single line through the error and entering the correct information. All corrections will be initialed and dated.

The serial number or identification number and disposition of all controlled documents (e.g., chain-of-custody forms) will be recorded in the SAM record coordinator’s document control logbook. If any documents are lost, a new document will be completed. The loss of a document and an explanation of how the loss was rectified will be recorded in the document control logbook. The serial number and disposition of all damaged or destroyed field documents will also be recorded. All voided and completed documents will be maintained in a project file until project completion, at which time all logbooks, unused tags and labels, chain-of-custody copies, etc., will be submitted to the SAM record coordinator.

The following is a list of all necessary field documents:

- chain-of-custody forms
- Sample logbook
- QAPjP
- FSP and attachments
- Health and safety plan.

7.1 Labels

All samples are identified by a sample label. Waterproof, gummed labels will be used. Labels may be affixed to sample containers before going to the field and can then be completed on the actual sample date. The label will contain the sample collection time and date, preservation used, type of analysis, etc. Labels will remain in the custody of the FTL or his designee when not in use. MCP-1192, “Chain-of-Custody and Sample Labeling for ER and D&D&D Projects,” establishes the container labeling procedure for this project.

7.2 Chain-of-Custody Forms

The chain-of-custody record is a form that serves as a written record of sample handling. When a sample changes custody, the person(s) relinquishing and receiving the sample will sign a chain-of-custody form. Each change of possession will be documented; thus, a written record that tracks sample handling will be established. The custody procedure for this project is established by MCP-1192.

7.3 Logbooks

Information pertaining to sampling activities will be entered in the sample logbook. Entries will be dated and signed by the individual making the entry. All logbooks will have a QC check for accuracy and completeness. MCP-1194, “Logbook Practices for ER and D&D&D Projects,” establishes the logbook use and administration procedure for this project.

8. HANDLING AND DISPOSITION OF INVESTIGATION-DERIVED WASTE

Waste generated from this project will be managed in accordance with the *Idaho National Engineering and Environmental Laboratory Waste Acceptance Criteria* (DOE-ID 2005) and Waste Generator Services direction. Wastes generated from sampling include personal protective equipment and miscellaneous materials (paper towels, plastic bags, gloves, etc.). Based on previous sampling at the RWMC wells, it is not anticipated that any miscellaneous sampling materials will become radiologically contaminated. However, if this does occur, the waste will be bagged, secured with duct tape, and labeled per the radiological control technician's instructions.

In the fall of 2002, several issues were raised regarding the applicability of RCRA-listed waste codes (specifically the F039 code for multi-source leachate) to waste generated below the SDA. It was determined that RCRA-listed codes did not apply to most waste generated from subsurface monitoring activities below buried waste. However, there was one exception. Samples collected directly below the buried waste are candidates for characterization as an F039 multi-source, leachate-contaminated hazardous waste if they originate at or above the 34-m (110-ft) interbed below the RWMC. Only one lysimeter being sampled under this investigation meets those criteria. It is lysimeter DL04, which was installed in Well TW1. This lysimeter was completed at 31 m (101.7) ft below land surface within the apparent confines of Pit 5 (see Figure 3-1 and Table 3-1).

Special consideration will be taken regarding management of waste generated from this (these) lysimeter(s). The FTL will work with Waste Generator Services and SAM personnel to ensure that waste generated from this (these) lysimeter(s) (including used or discarded sample material) is characterized appropriately and proper notifications are made to the laboratories conducting analysis of the samples. In addition, if cost-effective waste disposition is unavailable, some analyses, including the field analyses described in Subsection 5.2, may not be conducted.

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